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Effect of Neuropsychopedagogical Motor Intervention Program on Inhibitory Control, Working Memory and Cognitive Flexibility in Children with Attention Deficit Hyperactivity Disorder: A Randomised Controlled Trial

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Abstract

Background: Attention Deficit Hyperactivity Disorder (ADHD) is the most common neurodevelopmental disorder of childhood, occurring in 5-8% of school-aged children, and is characterized by a persistent pattern of inattention and/or hyperactivity- impulsivity that interferes with daily life functioning or development. Neuropsycholopedagogical Motor Intervention Program (NMIP) emphasizes activities that enhance hand and foot coordination by focusing on coding and decoding of body movements to promote motor development, executive functions and mindfulness.

Need of the study: Children with ADHD often show impaired executive functions such as inhibitory control, working memory and cognitive flexibility due to attention deficits and hyperactivity. Hence this study is conducted to explore the effect of NMIP on improving these functions.

Aim and objectives: To evaluate the effect of NMIP on inhibitory control, working memory and cognitive flexibility compared to conventional physiotherapy intervention.

Methodology: A total of 32 children diagnosed with ADHD according to DSM-5 criteria was randomly allocated into two groups, experimental group received conventional physiotherapy with NMIP and conventional group received physiotherapy intervention focusing on psychomotor function of 36 sessions. The pre and post evaluation was performed by using Trail Making Test, Head Toes Knees Shoulder Test and Childhood Executive Function Inventory.

Result : NMIP does not showed significant improvement ($p>0.05$) compared to conventional physiotherapy as the both the interventions are equally effective.

Conclusion: This study revealed that NMIP and conventional physiotherapy are equally effective to improves executive function and promote cognitive and motor development by coordinating motor activities in ADHD children.

Keywords: ADHD, NMIP, Executive functions

Introduction :

Attention-Deficit/Hyperactivity Disorder (ADHD) is a leading neurodevelopmental disorder in children, and the reported number of cases has been increasing. Prevalence rates are highly variable worldwide; however, various studies indicate that ADHD has a "pooled prevalence of about 7.1% for children and adolescents" in India[(1)]

It is characterized by a trio of core features: inattentiveness, impulsivity, and restlessness. The disorder manifests through a range of disruptive behaviors, including challenges like being easily distracted, preoccupied, forgetful, impatient, and overly talkative. These symptoms often disrupt a child's normal routine, leading to a negative impact on academic performance and daily activities .[(2) (3)]

This disorder is fundamentally linked to Executive Dysfunction, involving deficits in cognitive skills like working memory, inhibitory control, and planning. Symptoms such as forgetfulness, disorganization, emotional dysregulation, and impulsive actions disrupt daily life and academic performance. Undiagnosed or untreated ADHD can lead to long-term issues, including mood disturbances, relationship problems, and addiction in adulthood. [(3)]

Neuropsychopedagology developed predominantly remediation and reintegration interventions evidenced through intervention programs that involve promotion of cognitive health and stimulation of cognitive skills in students, in order to enhance the processes and lead to short to long term benefits an improvement in the development of fundamental skills of children. [(4) (5)]

Many studies suggests that Children with ADHD often show impaired executive functions such as inhibitory control, working memory and cognitive flexibility due to attention deficits and hyperactivity. Hence this study is conducted to explore the effect of Neuropsychopedagogical intervention on these functions.

Methodology:

The ethical clearance was obtained from the Institutional Ethical Committee (SSPC/IEC/171/2025) prior the study. A total of 32 children diagnosed with ADHD according to DSM-5 criteria was randomly allocated into two groups, experimental group receives conventional physiotherapy with NMIP and conventional group receives physiotherapy intervention focusing on psychomotor function of 36 sessions.

Inclusion criteria

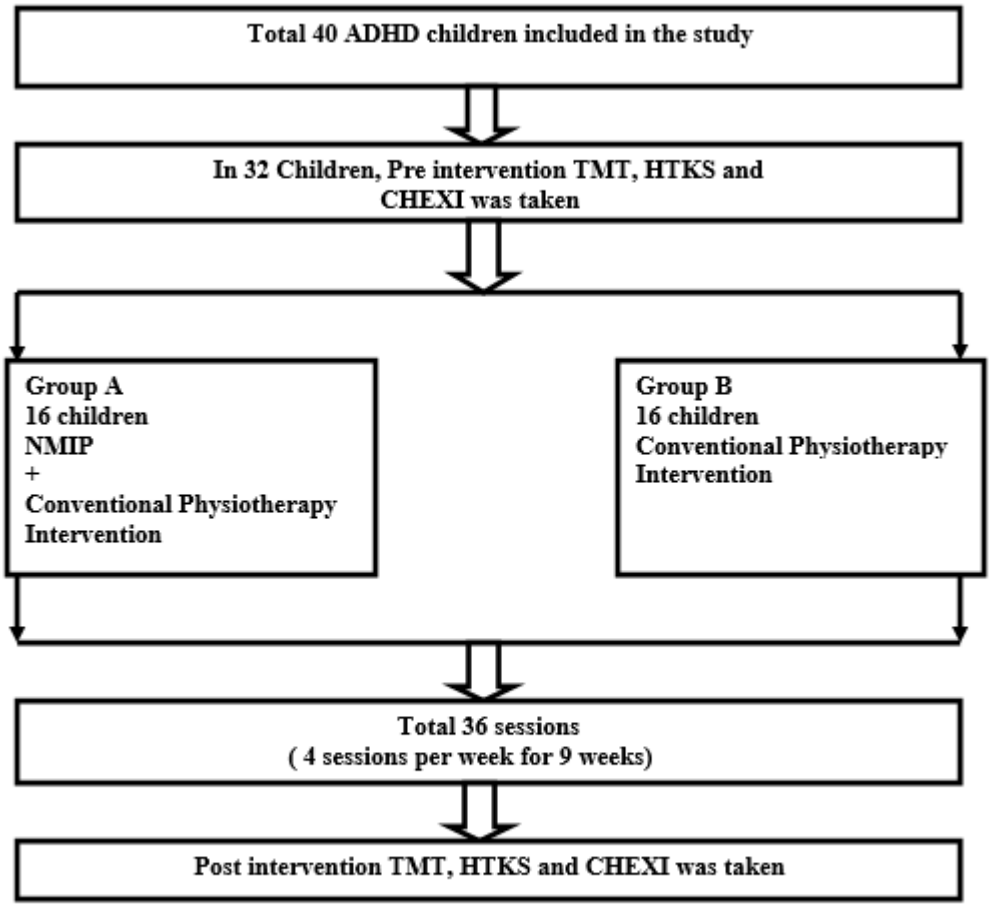
- Parent giving consent for participation
- Children aged 7 - 12 years, both male and female
- ADHD diagnosed according to DSM-5 criteria
- Children with Combined presentation (ADHD-C) type
- Regular participation in multidisciplinary treatrment

Exclusion criteria

- No visual or auditory impairments
- No severe psychiatric or neurological co-morbidities
- No cranial trauma, severe physical disabilities or major organ diseases

Outcome Measures

- **Trail Making Test (TMT) :** It is the one of the most widely used instrument for neuropsychological evaluation as it indicate the speed of cognitive processing and executive functioning. The test consists of two parts, part A and B and the direct score of each part is represented by the time of completion of tasks. [6]
- **Head-Toes- Knees-Shoulders Test (HTKS) :** The test is used to evaluate inhibitory control, working memory and cognitive flexibility. The test should be administered at spacious, well ventilated and well-lit room which ensures a comfort and distraction free environment. [4]
- **Childhood Executive Functioning Inventory (CHEXI) :** The Childhood Executive Functioning Inventory is a standardized questionnaire used to assess executive functioning in children aged 4–12 years. It primarily evaluates two core domains of executive function: working memory and



Procedure of the study

Intervention :

Conventional Intervention

- Static and Dynamic balance exercise, obstacle course exercise
- Vestibular play activity for sensory-motor integration
- Imitation games
- Fine motor activities

NMIP Intervention[4]

A----1. Balance on left foot (when see green square)

2. Balance on right foot (when see blue square)

B---- after 10 sessions

1. Green square : Balance on left foot
2. Blue square : Balance on right foot
3. Pink square : Tap both feet
4. Green circle : Lift only left arm
5. Blue circle : Lift only right arm
6. Pink circle : Raise both arms
7. Small pink circle : Clap

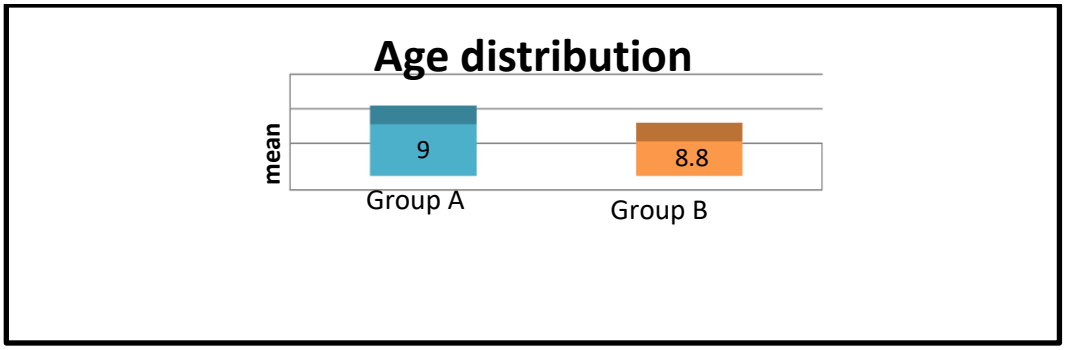
Balance on left foot **Lift left arm** **Clap**

Statistical Analysis:

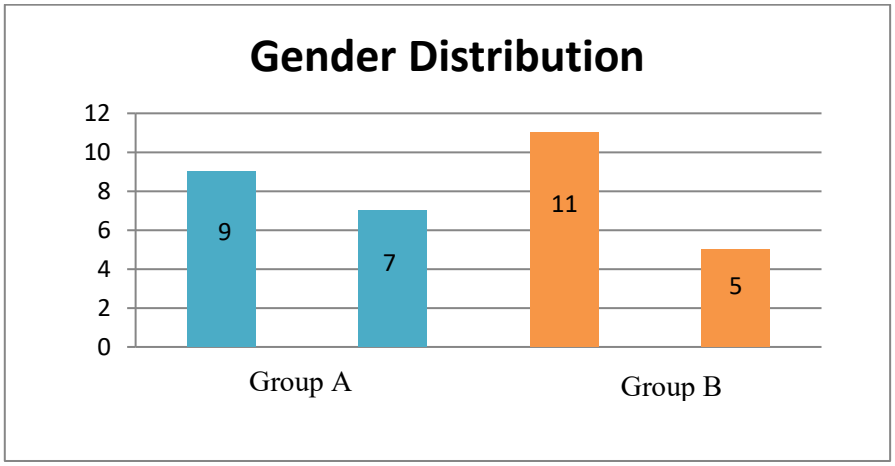
The data was screened for normal distribution by the Shapiro-Wilk test. As the data was not normally distributed the non-parametric test was applied for the within group and between group statistical analysis. For within group analysis Wilcoxon-signed rank test and between group Mann-Whitney U test was applied.

Result:

Total 32 children were included in the study, out of which 16 childrens were in conventional physiotherapy group and 16 were in NMIP group.

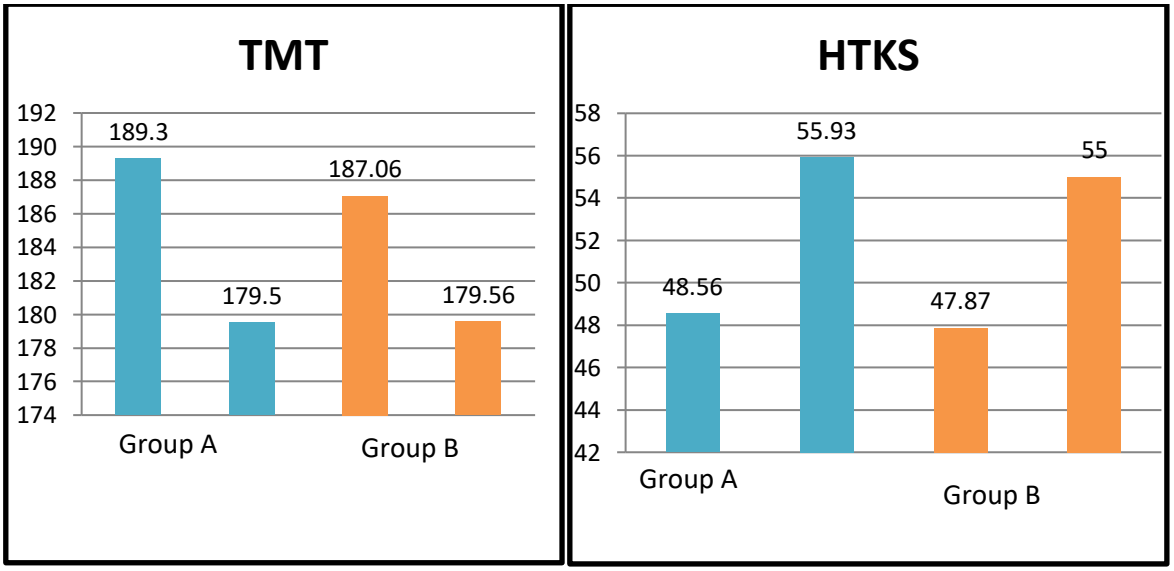


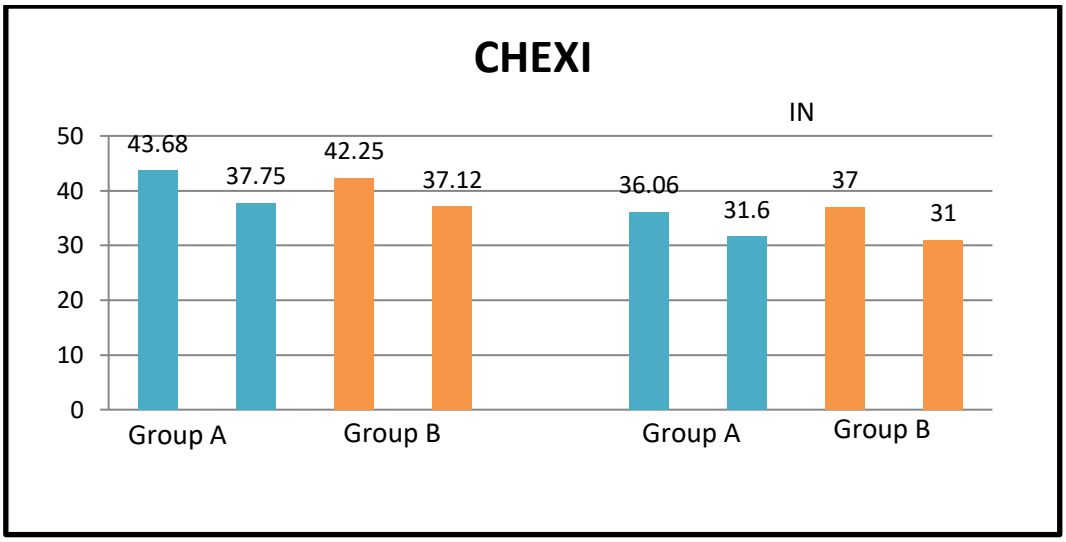
There were 16 participants in the each group, among that 9 male and 7 female in group A and 11 male and 5 female in group B.



The Wilcoxon signed-rank test revealed the significant improvement within the NMIP group as $p<0.05$

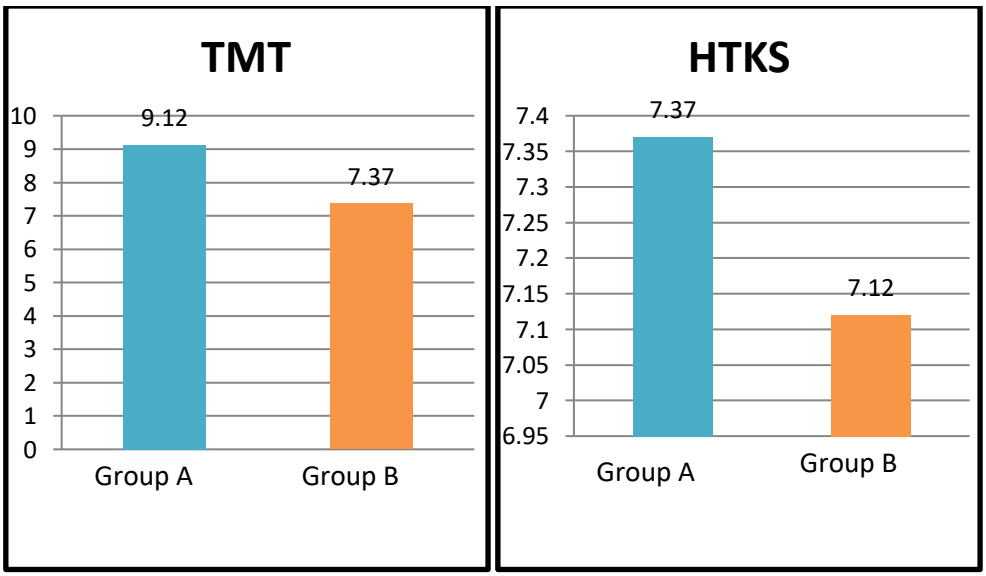
Outcome	Group A (Mean±SD)	Group B (Mean±SD)	p-value
TMT (Pre)	189.3±4.60	187.06±4.56	0.001
(Post)	179.5±6.0	179.56±3.81	0.001
HTKS (Pre)	48.56±3.89	47.87±2.47	0.001
(Post)	55.93±3.50	55.0±2.50	0.001
CHEXI –WM(Pre)	43.68±2.79	42.25±2.17	0.001
(Post)	37.75±3.00	37.12±2.80	0.001
CHEXI –IN(Pre)	36.06±2.37	37.0±2.42	0.001
(Post)	31.50±2.12	31.0±1.63	0.001

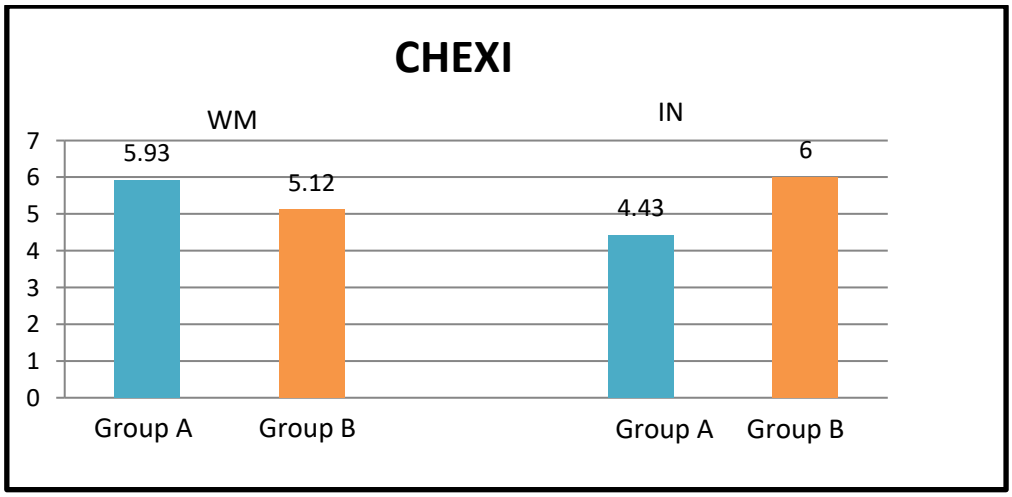




However, the Mann-Whitney U test for post intervention scores showed no significant difference between the NMIP group and Conventional group as p>0.05

Outcome	Group A (Mean±SD)	Group B (Mean±SD)	p-value
TMT	9.12±3.72	7.37±2.36	0.133
HTKS	7.37±3.13	7.12±2.02	1.00
CHEXI- WM	5.93±2.17	5.12±1.89	0.315
CHEXI-IN	4.43±1.67	6.0±2.42	0.056





This study suggests that both intervention can be beneficial in executive function in children with ADHD. However, NMIP was not superior to conventional physiotherapy.

Discussion:

This randomized controlled trial evaluated the effect of a Neuropsychopedagogical Motor Intervention (NMIP) on executive functions and motor performance in children with Attention Deficit Hyperactivity Disorder (ADHD). The results demonstrated significant improvements within both the NMIP and conventional physiotherapy groups; however, no statistically significant differences were observed between the groups.

The absence of significant between-group differences suggests that both interventions were comparably effective in improving inhibitory control, working memory, cognitive flexibility, and attention. These findings indicate that structured physiotherapy interventions, regardless of the specific therapeutic approach, can positively influence executive functioning in children with ADHD. The improvements observed within each group may be attributed to regular, goal-oriented physical activity, therapist guidance, and increased task engagement.

Although NMIP incorporates cognitive and attentional components within motor tasks, the lack of superiority over conventional physiotherapy may be explained by several factors. The duration and intensity of the intervention may have been insufficient to elicit differential effects between the two groups. Additionally, the small sample size may have limited the statistical power to detect subtle between-group differences. It is also possible that conventional physiotherapy, when delivered in a structured and child-centered manner, provides sufficient cognitive stimulation to yield comparable improvements in executive functions.

Motor learning principles such as repetition, task specificity, and feedback were common to both intervention protocols and may have contributed to the observed improvements. Furthermore, maturation effects and increased familiarity with assessment procedures could have influenced post-intervention performance in both groups.

These findings are consistent with previous literature reporting positive effects of physical activity–based interventions on executive function in children with ADHD, while also highlighting the difficulty in demonstrating superiority of one active intervention over another. The results emphasize the importance of active therapeutic engagement rather than the specific modality alone.

Conclusion:

The present study concludes that both Neuropsychopedagogical Motor Intervention and conventional physiotherapy are effective in improving executive functions and motor performance in children with Attention Deficit Hyperactivity Disorder. However, no significant differences were observed between the two intervention approaches.

These findings suggest that NMIP is comparable, but not superior, to conventional physiotherapy in managing executive function deficits in children with ADHD. Clinically, NMIP may be considered an alternative therapeutic option rather than a replacement for conventional physiotherapy.

Limitations:

The study may be limited by a relatively small sample size, which can affect the generalizability of the findings to the broader population of children with ADHD.

The current data focuses on immediate or short-term improvements; however, the long-term retention of functional gains and neural adaptations remains to be fully established.

Future recommendations :

Future studies with larger sample sizes, longer intervention periods, and follow-up assessments are recommended to further explore potential differential effects and long-term outcomes.

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